Residual correlation in two-proton interferometry from lambda-proton strong interactions [1]

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It has been shown that the lambda-proton (Λp) strong interaction induces a large peak in the correlation function [2]. The goal of this report is to investigate its residual effect in two-proton (pp) correlation with one proton from Λ decays (p_Λ), and to see if this residual correlation can account for the unexpected structure at $q \approx 70$ MeV/c in the pp correlation function measured by NA49 [3].

The pp_Λ invariant relative momentum q satisfies $q^2 = a^2k^2 - Qak\cos\theta + Q^2/4$, where Q is the Λ decay momentum, k the Λp relative momentum, θ the Λ decay angle, and $a = (1 + m_p/m_\Lambda)/2 \approx 0.92$. For a fixed q, the allowed k range is $k_- \le k \le k_+$, with $a^2k_\pm^2 = (q \pm Q/2)^2$. We have treated the problem non-relativistically because both Q and k are small relative to the proton or Λ rest mass.

The pair multiplicity distributions is $\frac{d^2N}{dqdk} = \frac{2q}{Qak}\frac{d^2N}{dkd\cos\theta} \propto \frac{qk}{Q}C_{\Lambda p}(k)$, where $d^2N/dkd\cos\theta \propto k^2$, and $C_{\Lambda p}(k)$ is the Λp correlation function. The pp_Λ correlation function is therefore $C_{pp_\Lambda}(q) = \int_{k_-}^{k_+} kC_{\Lambda p}(k)dk / \int_{k_-}^{k_+} kdk$. $C_{\Lambda p}$ is empirically Gaussian [2]: $C_{\Lambda p} = 1 + \lambda\exp(-k^2/2k_0^2)$. Thus, $C_{pp_\Lambda}(q) = 1 + \frac{\lambda a^2k_0^2}{qQ}[\exp(-\frac{(q-Q/2)^2}{2a^2k_0^2}) - \exp(-\frac{(q+Q/2)^2}{2a^2k_0^2})]$.

The NA49 two-proton correlation had 44% contamination in the proton pair sample. A Gaussian source size $R_g = 3.85 \pm 0.15$ (stat.) fm was extracted from the measurement [3]. The Λp correlation function for a $R_g = 3.85$ fm source is shown in Fig. 1a. Fitting the correlation function to a Gaussian yields $\lambda = 0.62$ and $k_0 = 21$ MeV/c. The calculated residual correlation function is superimposed in Fig. 1a. The residual correlation function peaks at $q \approx 40$ MeV/c with amplitude 0.05 (*i.e.*, a factor of $\sim$10 reduction).

Experimentally measured protons are a mixture of direct and weak decay protons. The pp correlation function for a $R_g = 3.85$ fm source for direct protons is shown as the thin solid curve in Fig. 1b. The Λ-decay contaminated correlation function, $0.56C_{pp} + 0.44C_{pp_\Lambda}$, is shown as the thick solid curve in Fig. 1b. We conclude that the residual correlation cannot explain the structure at $q \approx 70$ MeV/c observed by NA49 [3].

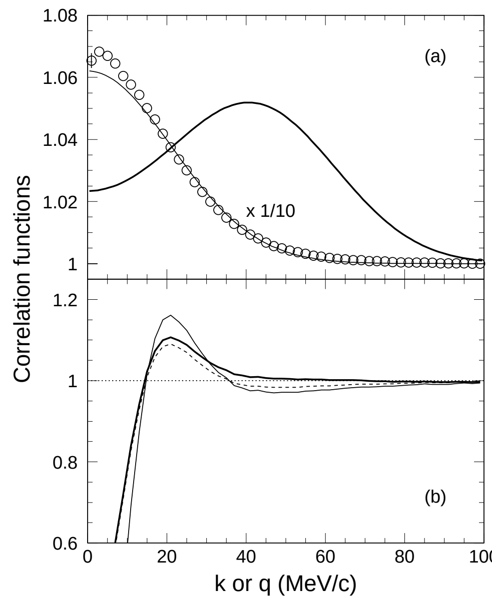

Figure 1: Upper panel: $C_{\Lambda p}$ for a $R_g = 3.85$ fm source (circles), a Gaussian fit to $C_{\Lambda p}$ (thin curve), and the resulting C_{pp_Λ} (thick curve). Lower panel: C_{pp} for a $R_g = 3.85$ fm source (thin solid curve), $0.56C_{pp}+0.44C_{pp_\Lambda}$ (thick solid curve), and $0.56C_{pp} + 0.44$ (dashed curve).

References

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[3] H. Appelshäuser *et al.* (NA49 Collaboration), Phys. Lett. **B467**, 21 (1999).